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(54) Washing machine with controlled detergent consumption, and control method thereof.

(57) A washing machine is described, particularly a laundry washing machine of the domestic type, comprising a system for controlling the detergent consumption.

The main feature of the described laundry washing machine is that it comprises means for detecting the detergent concentration in the washing liquid, means for estimating its optimal concentration and means for signalling the user with the result of the comparison between the detected detergent concentration and the optimal one, in order to educate him, wash after wash, in a more correct use of the detergent, so as to avoid useless waste and to reduce as far as possible the negative effects on the environment.

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The present invention refers to a washing machine, in particular a laundry washing machine of the domestic type.

It is known that, in general, the user of a laundry washing machine tends to introduce in the machine more detergent than is strictly necessary, thus causing a useless waste and a negative effect on the environment.

Laundry washing machines are known, having means for the automatic detergent dosage and also the problems being associated to such a function are known, which refer both to powder and liquid detergents.

In the case of powder detergents, the main difficulties are the following:

- several types of powder detergents exist, whose characteristics depend upon their volume (normal detergents and concentrated detergents), that make a volumetric-type dosage (that is actually the most diffused) very critical;
- great problems exist due to the progressive stratification of the powder detergents components, which are mainly characterised by different specific weights, because of vibrations generated by the washing machine, said vibrations being notable in the laundry washing machine above all during the spinning phases;
- finally, obvious humidity problems exist (always present in a washing machine) which, even if minimised by the use of suitable containers, cause however a progressive degeneration over time of the detergent's characteristics, due to the effect of oxidation processes.

In the case of liquid detergents for laundry washing machines, the main problems are the following:

- an automatic liquid detergent dosage, even if simpler to realise (at least apparently so), would not result however in being adequate, due to the fact that such a type of detergent presents more limited characteristics if compared to the powder ones; the liquid detergents cannot, in fact, contain the so-called bleaching agents (generally constituted by perborates and oxidants), inasmuch they are not stable in the liquid state;
- the realisation of the liquid detergent doser imposes the use of a container being rigorously hermetic and equipped with a suitable valve for the elimination of air, due to the fact that such type of detergent has the drawback, if contained in a non hermetic environment, of vaporising and progressively and remarkably increasing its viscosity, thus causing irreversible damage to the distribution apparatus of the dispenser.

The aim of the present invention is that of indicating how it is possible to realise a laundry washing machine that, in a simple and economic way, allows for the optimisation of the detergent consumption, so allowing to solve the problem of wastage and its negative consequences on the environment.

For reaching such aim, a washing machine is the subject of the present invention, in particular a laundry washing machine, having the characterising features of the annexed claim 1.

Further characteristics and advantages of the present invention will result in being clear from the detailed description which follows and from the annexed drawings, which are supplied purely as an explanatory and non limiting example, wherein:

- figures 1A and 1B illustrate respectively the operational principle of a device for measuring the resistivity of the washing liquid in a washing machine, and a possible embodiment thereof;
- figures 2A and 2B represent respectively the relation existing between the resistivity of the washing water (detected with the device of figure 1) and, respectively, the hardness and the concentration of detergent in such water;
- figures 3A and 4A relate to the proceedings of the water-level-renewal operations, respectively in the case of towelling and cotton fabric, and represent the sum of the times of the water-level-renewal operations, carried out by the first-level pressure switch (being expressed in seconds), in function of the quantity of clothes (being expressed in kg);
- figures 3B and 4B relates respectively to the towelling and cotton fabrics and represent the normalised Gauss function of experimental data relating to the total sum of the times of the water-level-renewal operations carried out by the first-level pressure switch, being associated to different quantities of clothes;
- figure 5 represents the composition of figures 3A and 4A on a same scale of ordinates and abscissas, for allowing the comparison;
- figures 6 and 7 relates respectively to towelling and cotton fabrics and represent the distribution in time of different water-level-renewal operations up of the first-level pressure switch or, in other words, the procedure of water supply in function of time;
- figures 8, 9 and 10 relate respectively to towelling, cotton and synthetic fabrics and represent the dynamics over time of the water absorption by the clothes introduced in the laundry washing machine;
- figure 11 is a comparison of the initial portion of the curves of the water absorption over time, relating to towelling, cotton, synthetic fibres and wool fabrics;
- figure 12 illustrates the link existing between the type of fabric and the time interval between the end of the first water supply and the start of the first water-level-renewal operation;

- figure 13 represents the normalised Gauss function of experimental data relating to the average duration of the water-level-renewal operations being associated to two pressure switches having different calibrations.

According to the present invention, the laundry washing machine has suitable means for carrying out the three following functions:

1. ESTIMATION OF THE OPTIMAL QUANTITY OF DETERGENT necessary in relation to the characteristics of the washing water and to the load of clothes to be washed;

2. DETERMINATION OF THE OUANTITY OF DETERGENT INTRODUCED BY THE USER;

3. INFORMATION TO THE USER CONCERNING THE CORRECT DETERGENT DOSAGE, in order to supply the user with a suitable feedback concerning the correctness, or not, of the quantity of detergent introduced, in order to educate him in a more appropriate use of the same, so as to avoid wastage and limiting as much as possible the negative effects on the environment (which depend upon the characteristics of the detergents actually available) .

The three operations cited above will be singularly analysed in the following of the present description.

1. ESTIMATION OF THE OPTIMAL OUANTITY OF DETERGENT

The washing machine realised according to the present invention has adequate means for estimating the optimal quantity of detergent, being necessary in relation to the characteristics of the washing water and the load of clothes to be washed.

This is allowed by the fact that, by means of suitable sensors means, the following information is available to the control unit of the machine, which is of the type comprising a microprocessor working in accordance with the fuzzy logic technique:

1.1) Water hardness
1.2) Ouantity of supplied water
1.3) Quantity of clothes to be washed
1.4) Type of fabric to be washed
1.5) Type of soil associated to fabrics
1.6) Suitable knowledge base, obtained through the experience of technicians and by means of experimental surveys, being encoded in the permanent memory of the microcontroller of the control unit.

1.1) Water hardness

The value of the water hardness may be determined by measuring its initial resistivity (i.e. before the introduction of the detergent), by means of a suitable measuring device, for example of the type as that being illustrated in figures 1A and 1B, that actually show possible embodiments of such a device. Furthermore, for exemplification, in figure 2A represents in graphic form the result of an experimental survey which illustrates the relation existing between the washing water hardness and the resistivity, detected by means of the device of figures 1A and 1B, in presence of a 20°C temperature.

Said device for measuring the resistivity of the washing water inside of a laundry washing machine comprises two electrodes, being indicated in figure 1A and 1B with letters A and B.

The electrode A is realised through an electrically conductive element, being in direct contact with the washing water, that in the case of figure 1A is the same metallic structure of the machine (tank-basket group), while in the case of figure 1B it is represented as being insulated from the same metallic structure by means of a suitable rubber gasket.

The electrode B is realised by means of an electrically conductive element being in direct contact with the washing water and insulated with respect to the electrode A. Said insulation can be obtained as indicated in figure 1B (and, more schematically, also in figure 1A), i.e. inserting the electrode B, which has the form of a small metallic cylinder, in a suitable hydraulic circuit, as a connecting means between two rubber tubes conveying the washing water. In particular, the rubber hydraulic circuit being represented in figure 1B is the so-called detergent-recovery circuit (see for example the Italian Patent No. 1.229.878, in the name of the present Applicant).

As can be seen in figure 1A, by connecting the electrode A to the positive pole of a generator E of continuous voltage (example E = 5V) and by connecting the electrode B to earth (negative pole of the same voltage generator E) through a capacitor C having suitable capacity (example C = 1mF), and considering that the washing water is certainly conductive, a current flow from A to B is obtained, which is proportional to the ionic concentration of the washing water.

Such a flow of current supplies the charge transitory of the capacitor C and stops when such transitory ends, i.e. when to the terminals of the capacitor C a voltage being equal to the value of E is present. The duration of the charge transitory depends upon the capacity value of the capacitor C and upon the value of the resisitivity of the means (the washing water) through which the charge current flows .

By establishing a suitable value of the capacitor C (for example C=1mF), it is possible to obtain information concerning the resistivity of the washing water through the measure of the duration of the charge time of the capacitor C itself. As shown in figure 1A, the measure of the dura-

tion of the charge time can be carried out by way of any commercially available microcontroller mP (with a 4 or 8 bit architecture) being able to measure the time with a good resolution (for example with the resolution of 1 mSec).

A digital input of the microcontroller mP, being indicated with INP in figure 1A, is connected to the terminals of the capacitor C, while its digital output, indicated with OUT, is used for controlling a transistor Q, being used as a switch, the collector of which is in turn connected to the terminals of the capacitor C.

The measure of the charge time of the capacitor C is carried out through the following operations of the microcontroller mP:

- fast discharge of the capacitor C, obtained by applying a short impulse (for example having the duration of 1 mSec) on the base of the transistor Q through the output OUT;
- start of the count of time in the instant in which, upon termination of the discharge impulse to the capacitor, the transistor Q returns in the interdiction state, thus allowing the start of the charge of the same capacitor;
- interruption of the count of time in the instant in which the voltage to the terminals of the capacitor reaches the reset threshold of the digital input INP, the value of which is typically equal to a half of the supply voltage of the microcontroller mP (i.e. E/2=2.5V);
- the value reached by the time counter being present inside of the mP, in the instant of the count interruption, constitutes the result of the measure and is in direct relation with the resistivity characteristics of the washing liquid. To this purpose, the microcontroller mP is conveniently programmed according to the fuzzy logic techniques, with an adequate base of knowledge, being encoded in the permanent memory (ROM) of the microcontroller, for realising the calculation of the resistivity presented by the liquid, following the measure of the charge time of the cited capacitor.

1.2) Quantity of water supplied

1.3) Quantity of clothes to be washed

1.4) Type of fabric

The total quantity of water supplied in the laundry washing machine according to invention may be determined by the use of a suitable turbine flow meter (for example of the type based on the Hall effect or infrared rays) or, even more conveniently, by using the information concerning the renewal of the washing water level being managed by the electromechanical first level pressure switch, as will be clarified in the following of the present description.

Known methods for measuring the weight of clothes in a laundry washing machine are the following:

- method of measuring the electric current (that is in relation with the torque) absorbed by the motor of the laundry washing machine, in order to place the basket with the clothes to be washed in motion;
- method of measuring the energy necessary for passing from a certain inertial state, being defined by a certain speed of the basket of the laundry washing machine, to another inertial state, being defined by a different speed of the same basket.

The type of the clothes loaded can on the other hand be derived by the study of its dynamics of water absorption.

In an embodiment being particularly advantageous of the present invention, the supplied water quantity and the quantity and/or the type of the clothes loaded are obtained in a simple and economic way, by monitoring the renewal interventions of washing water level, being managed by the electromechanical first level pressure switch, which is practically present on all commercially available laundry washing machines.

To said purpose, it should be remembered that the first level pressure switch of a laundry washing machine typically has the task of maintaining the water level constant, during the first phase of any washing program, with the double aim of ensuring the heating of the same, in a safe condition (i.e. with the heater always being immersed in the water) and ensuring the presence of a minimum liquid quantity, being necessary for carrying out an effective wash.

Such maintenance function of the water level, being realised by the pressure switch, consists in loading other water (by means of the activation of the suitable electrovalve) until the restoration of said level is obtained (which depends upon the calibration characteristics of the pressure switch), at any time that the same falls below a certain quantity (being expressed in mm-H2O and known as *differential or hysteresis* of the pressure switch) due to the effect of the absorption of the washing liquid by the clothes present inside of the laundry washing machine.

As will be clear in the following of the present description it is possible, from the examination of the behaviour over time of the first level pressure switch, to also obtain the information concerning the water quantity, the quantity of clothes and the type of fabric, being necessary for reaching the aims of the present invention.

The information extracted from the observation of the water level renewal processes of the first level pressure switch of a laundry washing

machine according to the present invention, are described in a graphic form in the following figures.

In particular, figures 3A and 4A, which refer respectively to towelling and cotton fabrics, describe the relation which exists between the quantity in weight (being expressed in kg) of fabric introduced in the laundry washing machine and the total time (being expressed in seconds) associated to the different water level renewal operations carried out by the first level pressure switch during the first phase of the washing cycle, until the absorption process of water by the clothes does not reach saturation.

As can be easily ascertained from the graphs in figure 4A and 4B, the overall duration of the water level renewal phases, i.e. the sum of the duration of the single water level renewal operations, (which is directly proportional to the quantity of water supplied, supposing the electrovalve flow rate as being constant) is linked to the weight of clothes to be washed by a simple linear relation.

In fact, as can be imagined, the greater the quantity of clothes introduced in the laundry washing machine, the greater the water quantity that the clothes subtract from washing chamber due to absorption and, consequently, the greater is the water quantity that must be "recalled" in the tank.

The fact that distinguishes towelling fabric from cotton is only the different slope of the two straight lines, as it is better illustrated in figure 5; thus, in other words, the speed of the water absorption differs for the two kinds of fabric (in particular it is greater for cotton than towelling).

From what has been explained above, it is clear that, once the type of fabric has been detected, (for example in the way that will be described) and knowing the sum of the duration of the single water level renewal operations, also its quantity may be determined, as shown from the figures 3A, 4A and 5.

The values being represented in figures 3A and 4A are average values, derived from a high number of experimental tests carried out with different fabric loads. The quality of the information being associated to such average values is made evident by the low dispersion shown by figures 3B and 4B, which relate respectively to towelling and cotton and represent the normalised Gauss function of the sums of the times of the water level renewal operations being associated to the different cloth quantities placed under observation.

Figures 6 and 7 represent the result of two experimental surveys, which refer respectively to a washing load of 4 kg of towelling and cotton fabrics: such figures make evident the dynamics of the water level renewal operations over time and express in more intuitive way the quality of the information being associated to the operation of the electromechanical first level pressure switch; for example, it is possible to detect

- the different number of water level renewal operations (twelve for towelling and nine for cotton),
- the different distribution over time of the water level renewal operations associated to a same quantity of towelling and cotton cloths,
- the different total duration of the water level renewal operations depending upon the fabric type,
- the different duration of the pause elapsing between the first water supply and the first renewal operation of the level of the same, carried out by the pressure switch, depending upon the fabric type,

this information allows to manage the machine and the method according to the invention, as will be better understood in the following of the present description.

The previous examined figures 3, 4, 5, 6 and 7 mainly illustrate the stationary situation which is reached at the end of the water absorption process by fabrics, and highlight the fact that the quantity of clothes and the fabric type are functions both of the sum of the times of the water level renewal operations and their number.

However, such relations are not independent from each other, because in practice they describe the same phenomenon by different parameters.

In order to have further information, being necessary for extracting in an independent way the value of the quantity of clothes and the fabric type, the dynamic evolution of the water absorption process by the fabrics has been examined in greater detail.

The result of such an experimental survey is reported in figures 8, 9, 10, 11 and 12.

In particular, figures 8, 9 and 10 represent the relation of the exponential type (which is typical for process being characterised by saturation) that describes the absorbed water quantity in the time by different quantities of fabric, with regards respectively to towelling, cotton and synthetics.

On the ordinates axis the water quantity is shown (being expressed in litres), supplied during the water level renewal phases of the pressure switch, and on the abscissas axis the sum of times (being expressed in seconds) is reported of the pauses elapsing between one water level renewal operation and another, i.e. the speed with which the clothes absorb the washing liquid.

From an examination of such figures we can detect that the initial proceedings of the curves being associated to the different quantities of

clothes is practically independent from the same quantity and mainly depends upon the type of fabric, as it is better explained in fig. 11, wherein the slopes of the absorption curves of the different fabrics have been reported (figures 8, 9 and 10), being calculated in the area of the cartesian axes origin.

Even if the validity of the proceedings reported in fig. 11 is limited to a area being restricted to the origin, they evidence however a very important aspect: the fact that it is possible to deduce the type of fabric by observing the behaviour of the pressure switch in the first phase of the water supply and, in particular, by the simple measure of the duration of the pause elapsing between the first water supply and the first operation of renewal of the water level carried out by the pressure switch.

This is even better explained by fig. 12 (which links the proceedings in the area of the origin of fig. 11 to the real physical phenomenon of the water absorption controlled by the pressure switch), wherein on the ordinates axis the value (being expressed in litres) of the water supplied in occasion of the first water level renewal operation is reported, which is practically independent from the fabric type, and on the abscissas axis the value (being expressed in seconds) of the pause elapsing between the end of the initial water supply and the beginning of the first renewal operation of the water level carried out by the pressure switch is shown.

The water supplied in occasion of the first water level renewal operation (ordinates axis) has the aim to restore up to the initial value (that referring to the instant wherein the first supply ends) the level of the washing liquid, therefore exactly compensating the quantity absorbed by the clothes in the time interval between the end of the first supply and the beginning of the first water level renewal operation itself (abscissas axis).

From an examination of figure 12 the different slope is evident, that characterises the different kinds of fabrics and that physically expresses the different speed of the water absorption by the same.

From what has just been described with regards to figures 11 and 12, it therefore appears clear how it is possible to recognise the type of fabrics introduced in the laundry washing machine, by the simple measure of the duration of the pause which elapses between the first water supply and the first renewal operation of the level of water carried out by the pressure switch. Thus, once the type of fabric has been obtained in such a way, as a consequence its quantity is also detected, as shown in the above described figures 3A, 4A and 5.

It should also be considered the fact that the data reported in figure 12, even if they have the important advantage of being independent from the quantity of clothes introduced in the laundry washing machine, however depend upon the characteristics of the pressure switch, and in particular from the value of its differential or hysteresis: for such a reason, it is necessary to know the differential of the first level pressure switch, which is therefore an imposed parameter. In other words, the pressure switch differential is a parameter initially encoded inside the microcontroller's permanent memory of the control unit of the laundry washing machine according to the invention; to such a parameter a part of the information describing the links which exist between the values derivable from the monitoring of the pressure switch is then correlated, this latter information also being encoded in the non volatile memory of the microcontroller.

It should however be considered that the laundry washing machine according to invention is in itself able to obtain the effective value of the pressure switch differential: such a value is in fact directly proportional to the average duration of the water level renewal operations, which may be obtained by dividing the sum of the times being associated to the different renewal operations for their number. Thus, with an opportune programming of the microcontroller, the laundry washing machine is in the condition of measuring constantly, automatically and with precision the differential, or hysteresis, of the pressure switch: in the case of decalibration of the latter (and therefore in the case of discrepancies between the initially imposed hysteresis value and the effective values successively detected), the microcontroller can provide the updating, according to suitable criteria derived from the modern learning software techniques (learning algorithms), of the hysteresis value initially imposed as a project parameter.

The above described method for determining the quantity and/or the type of fabric is based on the observation of "natural" water level renewal operations of the pressure switch, i.e. those renewal operations of the level being caused directly by the closure of the empty contact of the pressure switch, which allows to excite the water supply electrovalve.

A possible variation of such a method, that brings about analogue results, consists in considering the case of the observation of "forced" renewal operations of the water level, by using the empty contact of the pressure switch solely for sending a criteria to the control system, rather than directly exciting the water supply electrovalve, which will be managed by the same control

system by way of a suitable actuator (e.g. a relay).

Therefore the control system, after having carried out the first water supply keeping the clothes steady, will begin to suitably rotate the basket of the laundry washing machine (for favouring the water absorption by the clothes) and will steadily maintain this situation for an established time T, the duration of which will be such as to allow the pressure switch to reset, i.e. its passage from the full to empty state.

Once said time interval T has elapsed, the control system will provide to excite the water supply electrovalve until the water level is restored, i.e. until the pressure switch has not passed from the full to empty state.

The quantity of water that the system must load to restore the initial level will represent the liquid quantity that the fabrics have absorbed during the pause T, i.e. it will give information about the kind of water absorption by the clothes, and therefore on the type of fabric. Such a variation to the method according to invention has thus the advantage of being independent from the characteristics of the pressure switch, in particular from its differential.

Figure 13 in fact shows the different average value of the duration of the water level renewal operation associated to two different laundry washing machines (shown in the figure as machine A and machine B) being characterised by two pressure switches having a differential respectively of 23 mm-H2O (machine A) and 20 mm-H2O (machine B).

1.5) Type of soil

The type of soil and its entity are values which can hardly be measured in a direct way; it is however possible to estimate their value by means of indirect measures, the better known of which are those of the optical type, which are realised by measuring the turbidity of the washing liquid.

A alternative method to the optical one, according to a particularly advantageous embodiment of the laundry washing machine subject of the present invention, is based on measuring the water resistivity, that is easily carried out by means of the measuring device described with reference to figures 1A and 1B, and therefore without the necessity of any additional cost. The detection of the entity of the soil, by means of the cited device, has a significant importance in anomalous conditions of soil, for example in the cases wherein the clothes to be washed are very dirty.

Eventually, the information referring to the soil entity could be an input supplied by the user, for example by means of a suitable command device.

1.6) Knowledge base

The knowledge base, regarding the estimation of the optimal detergent quantity, is obtained with the aid of experts in the field of washing and by means of experimental surveys, and is encoded, inside the permanent memory of a microcontroller in the form of "rules" (IF...THEN rules) by means of the fuzzy logic techniques.

Such a knowledge base contains the criteria for determining the optimal quantity of detergent in function of the value of the quantity being obtained in the above described ways, i.e. in function of the water hardness, the quantity and the type of fabrics to be washed, the entity and the type of soil and finally the quantity of water supplied.

2. DETERMINATION OF THE QUANTITY OF DETERGENT INTRODUCED BY THE USER;

As can be imagined from what has been described above, the laundry washing machine according to the invention has adequate means for also detecting the quantity of detergent introduced by the user before initiating the washing cycle: such detection means are in great part the same as those being used for the estimation of the optimal detergent quantity. In fact, the following information is available to the control unit of the fuzzy logic type:

2.1 Water hardness

2.2 Total quantity of water supplied

2.3 Water temperature

2.4 Ionic concentration of the washing liquid, after the introduction of the detergent

2.5 Suitable knowledge base, always obtained through the experience of technicians and by means of experimental surveys, and encoded in the permanent memory of the microcontroller of the control unit.

2.1) Water hardness

To this extent note that previously described in point 1.1.

2.2) Water Quantity

As already said, also for determining the quantity of detergent introduced by the user, the hardness and the quantity of the water are measured with the above described means; in particular, the water hardness is derived from the measure of the resistivity, through the device of figures 1A and 1B, while the measuring of the water quantity is obtained by means of the information associated to the water level renewal operations carried out by the electromechanical first level pressure switch.

2.3) Water temperature

The value of the temperature of the washing water is determined by means of a suitable low-

cost sensor, for example having a thermo-responsive element of the NTC type, i.e. realised by a mixture of oxides whose resistance changes in an inverse way with respect to the temperature, according to an exponential type law rule.

2.4 Ionic concentration of the washing liquid

The value of the ionic concentration of the washing liquid after the introduction of the detergent is determined in the same way as the value of the water hardness is determined, as described above, i.e. through measuring the liquid resistivity after the introduction of the detergent. For example, in figure 2B the result of an experimental survey that illustrates the relation existing between the detergent concentration and the resistivity is represented in a graphic form, detected by means of the device of figures 1A and 1B, in presence of a temperature of 20°C and for a water hardness value of 30°F.

Also in relation with that previously described in point 1, it should be specified that the control system of the laundry washing machine provides, in opportune instants, to measure the resistivity of the washing liquid, by means of the device illustrated in figures 1A and 1B, and to carry out the comparisons eventually necessary of the detected values; such measurements can, for example, occur before that in the washing water the detergent is introduced (for the measure of the water hardness), after that the detergent has been introduced in the washing water (for measuring the ionic concentration of the washing liquid), at the end of the washing phase (for example for having further indications concerning the soil entity), at the end of the rinsing phase (for measuring its quality).

2.5) Knowledge base

The knowledge base contains in this case the criteria for the estimation of the quantity of detergent introduced by the user, in relation to the values obtained in the above described ways, i.e. the value of the hardness, the temperature and the quantity of water and on the basis of the ionic concentration of the washing liquid.

3. INFORMATION ON THE CORRECT DETERGENT DOSAGE

The laundry washing machine according to invention has finally suitable **interface means** for supplying the user with an appropriate feedback concerning the correctness, or not, of the quantity of detergent that has been introduced.

As described in the above points **1.** and **2.**, the control unit of the system has, through the cited sensor devices and its own memorised knowledge, information relating to **the estimation of the optimal detergent quantity** and to **the detection of the quantity of detergent introduced by the user.**

In addition, the control unit is equipped with a non volatile memory of the EEPROM type (Electrically Erasable Programmable Memory) and can therefore acquire **indications on the user's habits**, having regards to the type of the average load of clothes, the quantity and the average type of soil and the prevalent way of using the detergent.

Such indications are detected over time, wash after wash, through the sensor and detection means cited above, and stored in the aforementioned non volatile memory, which is updated time after time according to opportune criteria derived from modern learning software techniques (learning algorithms).

The control unit moreover has a further knowledge base (which is also obtained through the experience of technicians and by means of experimental surveys, and encoded in the permanent memory of the microcontroller of the control unit), containing the criteria for supplying the user, by means of the cited interface means, with a qualitative and/or quantitative judgement on the degree of correctness concerning the quantity of the detergent introduced, which is evaluated on the basis of the comparison between the optimal theoretic quantity and the estimation of that effectively introduced, and taking into account the information on the user's habits, stored over time by the control unit.

The interface means or, in other words, the way of informing the user about the correctness, or not, of the detergent dosage he has used can be of different types, depending on the adopted signalling means.

For example a suitable display (LED, or LCD, or fluorescent type) could be used for showing the degree of distance (in defect or in excess) in respect of the optimal dose of the detergent, being provided in relation to the characteristics of the water and the clothes present in the laundry washing machine.

For example an acoustic signalling device could be used, such as one or more buzzers having different sounds or tones, or a vocal synthesiser with messages of the type "DETERGENT IN EXCESS" or "DETERGENT IN DEFECT" or "CORRECT QUANTITY OF DETERGENT".

In the same way, a display means of a simplified type (more economic) could be used, based on the use of simple luminous lights or, as an alternative, an index-type electric instrument, for example of the moving-coil type, duly connected to the control system.

In any case, whatever the type of signalling means, this always remains within the innovative idea, subject of the present invention.

As previously said, an excellent method for encoding in a compact form the great quantity of information that the control unit has to deal with, is that supplied by the control technology based on the fuzzy logic, which is already widely used in the field of con-

sumer products and, in particular, in the field of household appliances. The knowledge bases of the method according to invention, being obtained as described above, are encoded, inside of the permanent memory of the microcontroller in the form of "rules" (IF...THEN rules) by means of the fuzzy logic techniques.

Considering that almost all modern laundry washing machines are equipped with a microcontroller, it appears evident that the latter, once duly programmed, allows to obtain in the described ways the required information: the innovative idea can therefore find applications in the traditional laundry washing machines, i.e. those having an electromechanical timer, provided that they are characterised by the presence of a microcontroller in an electronic sub-ensemble (for example the microcontroller being present in the digital electronic module for the control of the motor speed).

To this purpose, it should also be emphasised that the implementation of the invention, according to the above described advantageous embodiments, has a very low cost; in fact the pressure switch is practically already present on all washing machines (for security and normative reasons), the cost of the microcontroller (if it is not already provided on the laundry washing machine) is in the order of $1; in the same way, the cost of the components of the device for measuring the water resistivity, the temperature sensor and the signalling light is second place concerning the utility of the control system of the machine being the subject of the present invention.

From the given description the characteristics and the advantages of the present invention are therefore clear, according to which it is possible to estimate the optimal detergent quantity being necessary in relation to the characteristics of the washing water and of the clothes to be washed, to detect the quantity of detergent introduced by the user, and to supply the user himself, after termination of the washing cycle, with an appropriate feedback concerning the correctness, or not, of the quantity of detergent introduced. In such a way, it is therefore possible to "educate" the user, wash after wash, to acquire criteria for a most correct evaluation of the quantity of detergent to be used on the basis of the characteristics of the clothes to be washed (which are sufficiently known to the user himself) and of those of the washing water (which are known by the control system according to the invention).

It is finally clear that several variants are possible to the laundry washing machine subject of the present invention, without departing from the novelty principles inherent in the innovative idea.

It is finally clear that a part of the information useful for the operation of the above described machine (for example that being useful for the determining the optimal concentration of the detergent) could be input by the user, by means of suitable command devices of the traditional type, which are in any case often present on the laundry washing machines. For example, the possibility is cited of using the monitoring of the pressure switch only for obtaining the information relevant to the quantity of clothes, and in this case the information relating to the type of fabrics could be input to the machine directly by the user, for example by means of a selector or buttons; in the same way the information relative to the type of soil could be supplied to the machine.

Claims

1. Washing machine, particularly a laundry washing machine of the domestic type, characterised in that it comprises means for detecting the detergent concentration in the washing liquid, means for estimating its optimal concentration and means for signalling the user with the result of the comparison between the detected detergent concentration and the optimal one.

2. Washing machine, according to claim 1, characterised in that said means for detecting the detergent concentration in the washing liquid and/or said means for estimating the optimal concentration of the detergent comprises:
   - means for detecting the washing liquid hardness and/or
   - means for detecting the quantity of the liquid supplied and/or
   - means for detecting the liquid temperature and/or
   - means for detecting the ionic concentration of the washing liquid after the introduction of the detergent, and/or
   - means for detecting the quantity of clothes to be washed and/or
   - means for detecting the type of fabric to be washed and/or
   - means for detecting the entity and/or the type of soil of the clothes to be washed.

3. Washing machine, according to claim 1, characterised in that said means for signalling the user with the result of the comparison between the detected detergent concentration and the optimal one are of type able to show the degree of difference between the optimal detergent quantity and that detected, said means for signalling include in particular luminous lights and/or a LED or a LCD or a fluorescent type display, and/or an indicator device having a movable index.

4. Washing machine, according to claim 2, characterised in that a device is provided for measuring

the resistivity of the washing liquid, which is used for:

- measuring the washing liquid hardness and/or
- detecting the ionic concentration of the washing liquid after the introduction of the detergent and/or
- measuring the entity and/or the type of soil on the clothes.

the measuring of one or more of said parameters being in particular carried out in an indirect way through the measuring of the resistivity of the washing liquid.

5. Washing machine, according to the previous claim, characterised in that said device for measuring the resistivity of the washing liquid comprises two electrodes (A,B), being in contact with the washing liquid and inserted in the charge circuit of a capacitor (C), and means (mP, Q) for measuring the charge time (Tc) of said capacitor (C), the measure of the resistivity being obtained in an indirect way through the measuring of said charge time (Tc).

6. Washing machine, according to claim 2, characterised in that said means for detecting the quantity of liquid supplied comprises
   - a turbine flow meter and/or
   - a pressure switch, in particular of the electromechanical type, the detection of said liquid quantity being obtained by monitoring through control means (mP) the interventions for restoring the washing liquid level carried out by said pressure switch.

7. Washing machine, according to claim 2, characterised in that said means for detecting the quantity of clothes to be washed comprise means for measuring the current absorbed by the motor of the machine for placing the basket containing the clothes in motion, and/or means for measuring the energy necessary for passing from a first inertial state, defined by a certain speed of the basket, to a second inertial state, defined by a different speed of the same basket.

8. Washing machine, according to claim 2, characterised in that said means for detecting the type of clothes to be washed comprise a level sensor, the detection of the type of clothes to be washed obtained by monitoring through control means (mP) the interventions for restoring the washing liquid level controlled by said sensor.

9. Washing machine, according to the previous claim, characterised in that said level sensor is an electromechanical first level pressure switch and in that the information relating to the fabric type introduced is obtained through measuring the pause elapsing between the first supply of washing liquid in the laundry washing machine and the first restoration of the liquid level carried out by the pressure switch.

10. Washing machine, according to claim 2, characterised in that said means for sensing the quantity of clothes to be washed comprise a level sensor, the detection of said quantity of clothes to be washed being obtained by monitoring through control means (mP) the interventions for restoring the washing liquid level controlled by said sensor.

11. Washing machine, according to the previous claim, characterised in that said level sensor is an electromechanical first level pressure switch and in that the information relating to the quantity of clothes introduced is obtained through measuring the total time of the different operations of water level restoration, carried out by the pressure switch in the first phase of the washing cycle, and on the basis of the type of fabric.

12. Washing machine, according to one or more of the previous claims, characterised in that it comprises a microcontroller (mP), which in particular carries out the count of said charge time of said capacitor (C) and/or the monitoring of the water level restoration operations of said pressure switch, and permanent memory means (ROM) and/or non volatile memory means (EEPROM) associated to said microcontroller (mP), in said memory means being encoded, in particular in the form of "rules", the criteria for:
   - determining the quantity of detergent introduced by the user, in function of the value of the quantity of the liquid supplied, and/or its hardness, and/or its temperature and/or its ionic concentration, and/or
   - determining the optimal quantity of detergent in function of the value of the quantity of the liquid supplied, and/or its hardness, and/or the quantity and/or the type of clothes to be washed, and/or the entity/type of soil; and/or
   - supplying the user with information on the degree of correctness of the quantity of detergent introduced, evaluated on the basis of the comparison between the optimal quantity and the quantity effectively introduced.

13. Washing machine, according to the previous claim, characterised in that said microcontroller and said non volatile memory means (EEPROM)

are able to acquire information on the user's habits, in particular having regards with the average type of the laundry load, the average quantity and type of the soil and the way of using the detergent.

14. Washing machine, according to the previous claim, characterised in that said information is detected over time, wash after wash, through said means for detecting the washing liquid hardness, and/or the liquid quantity supplied and/or the liquid temperature and/or the ionic concentration of the washing liquid after the introduction of the detergent, and stored in a suitable non volatile memory (EEPROM), which is updated time after time, in particular according to criteria deriving from learning software techniques (learning algorithms).

15. Method for the control of detergent consumption in a washing machine, in particular a laundry washing machine for domestic use, characterised by the following steps:
    - estimating, in relation to the characteristics of the washing water, the quantity and/or the type of clothes to be washed and/or of the entity of the soil, the optimal detergent quantity being necessary for carrying out an effective wash;
    - detecting the detergent quantity effectively introduced by the user at the beginning of a washing cycle;
    - comparing the optimal detergent quantity with the quantity of detergent effectively introduced;
    - signalling the user with the result of the comparison between the detected detergent concentration and the optimal one, in particular in order to progressively educate the user, wash after wash, in a more correct use of the detergent.

16. Method, according to the previous claim, characterised in that the estimation of the optimal quantity of the detergent is carried out in function of the washing liquid hardness and/or the quantity of supplied liquid and/or the quantity of clothes to be washed and/or the entity and/or the type of soil of the clothes to be washed and in that the detection of the quantity of detergent introduced is carried out in function of the washing liquid hardness and/or the quantity of liquid supplied and/or the ionic concentration of the washing liquid after introduction of the detergent.

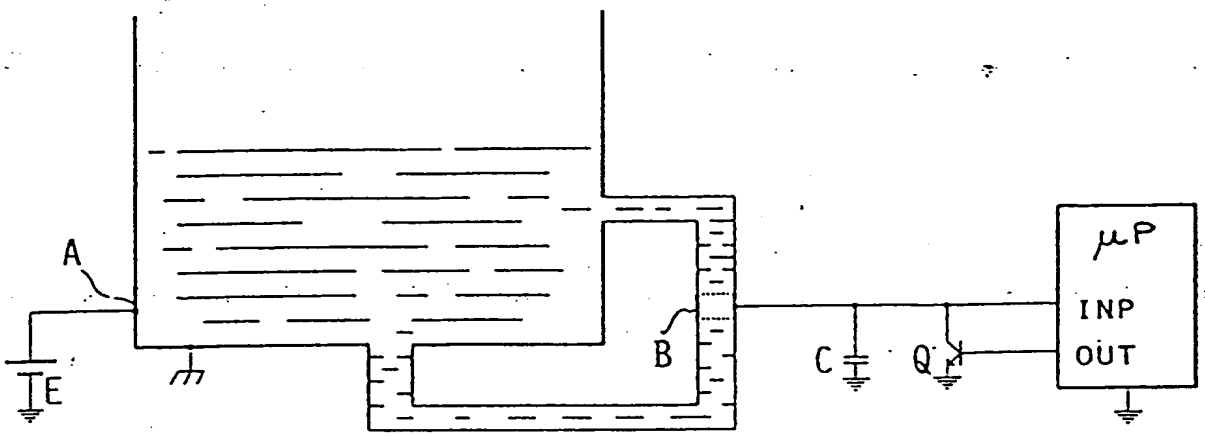

FIG. 1A

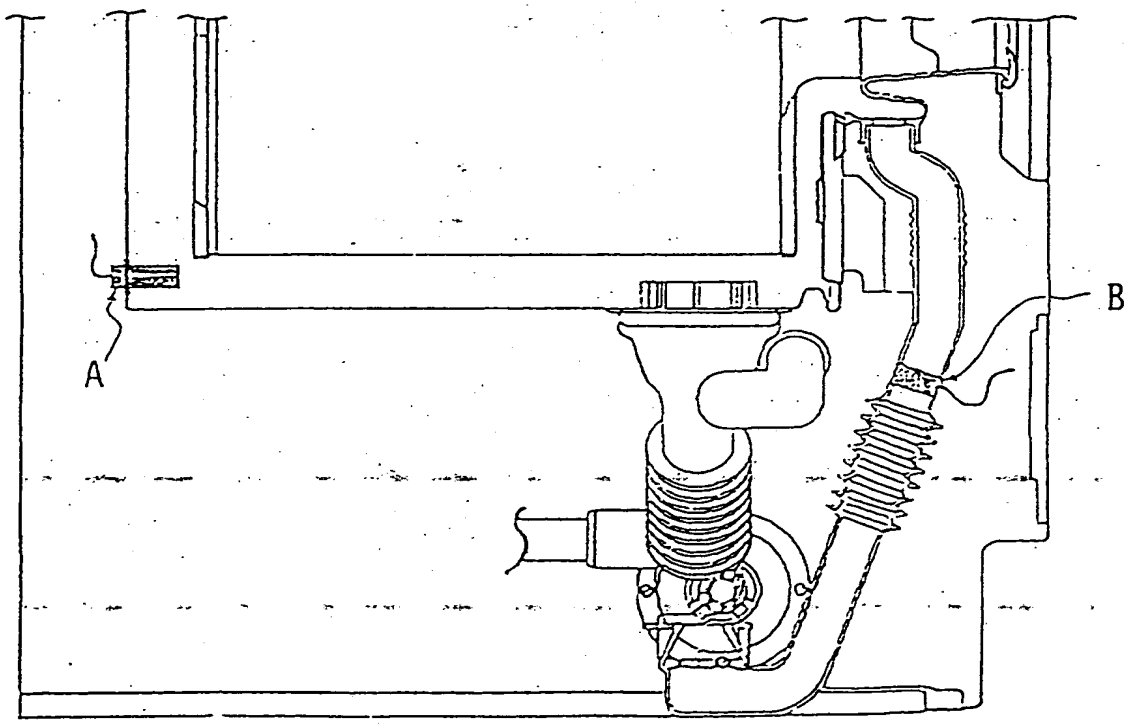

FIG. 1B

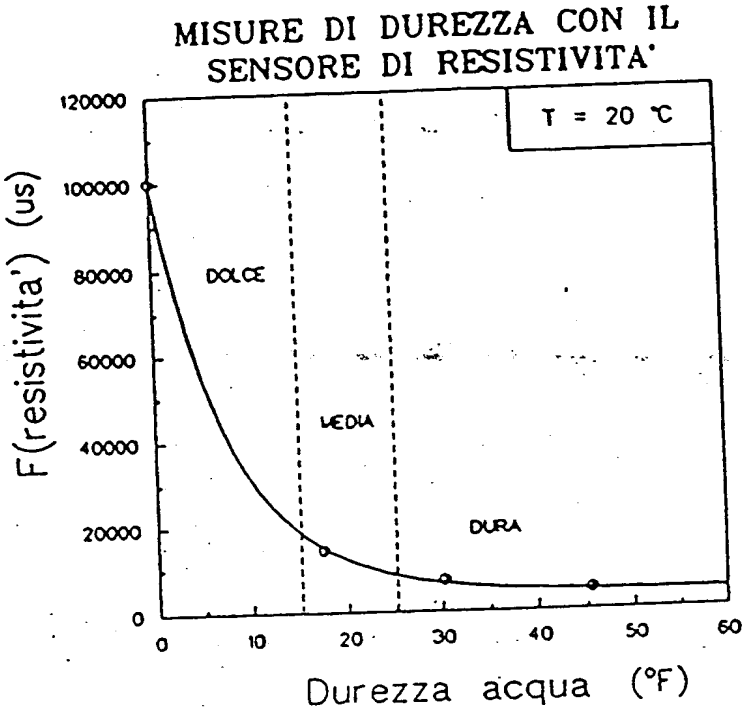
MISURE DI DUREZZA CON IL SENSORE DI RESISTIVITA'
T = 20 °C
F(resistivita') (us)
120000
100000
80000
60000
40000
20000
0
DOLCE
MEDIA
DURA
0
10
20
30
40
50
60
Durezza acqua (°F)

FIG. 2A

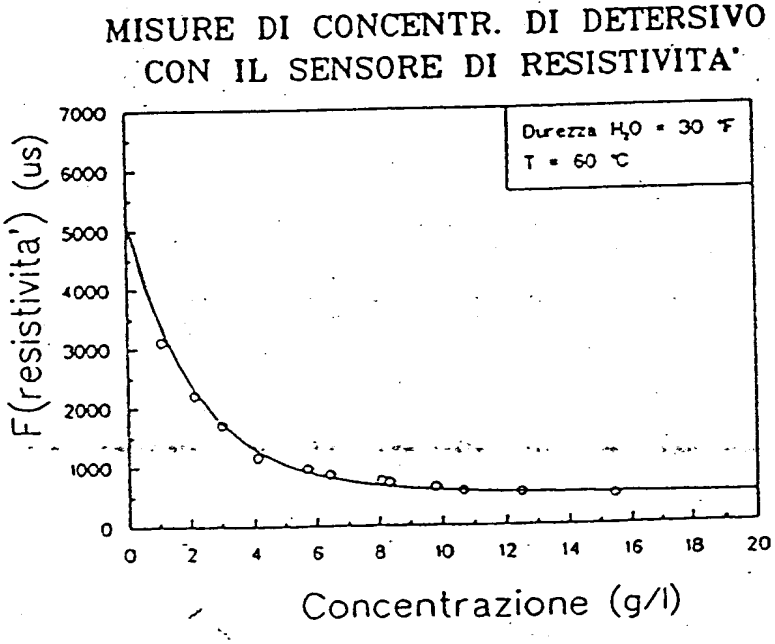
MISURE DI CONCENTR. DI DETERSIVO CON IL SENSORE DI RESISTIVITA'
Durezza H2O = 30 °F
T = 60 °C
F(resistivita') (us)
7000
6000
5000
4000
3000
2000
1000
0
0
2
4
6
8
10
12
14
16
18
20
Concentrazione (g/l)

FIG. 2B

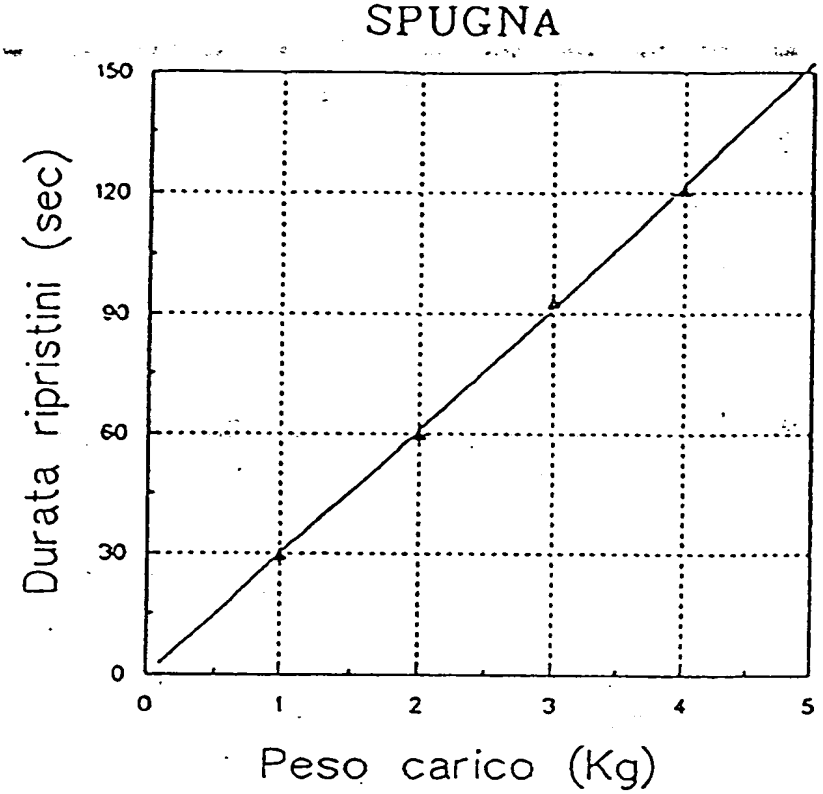

FIG. 3A

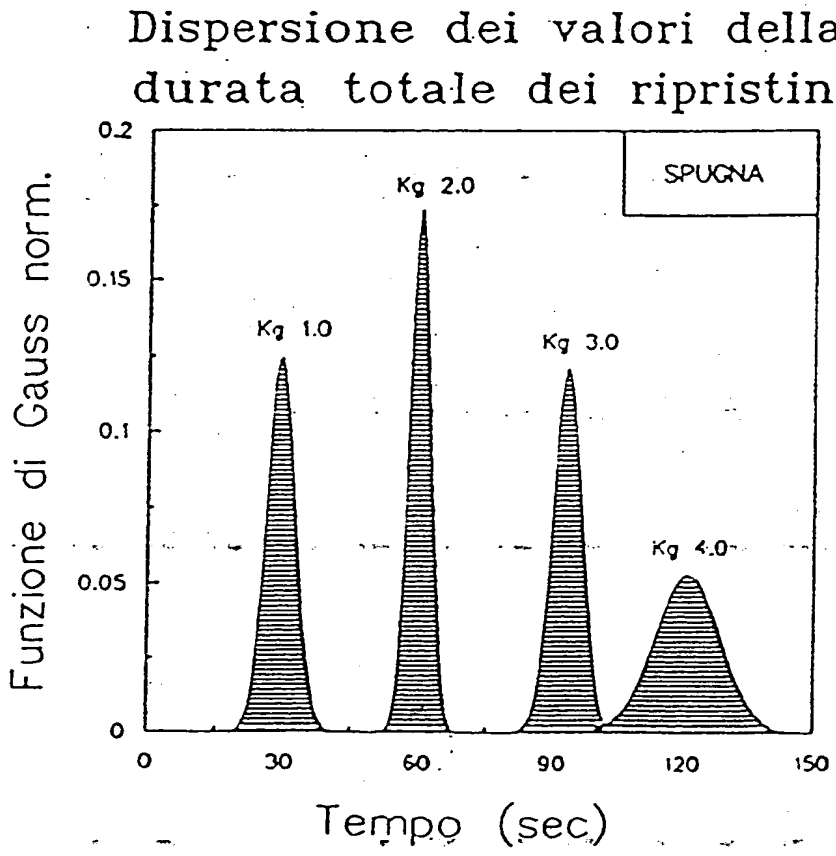

FIG. 3B

COTONE

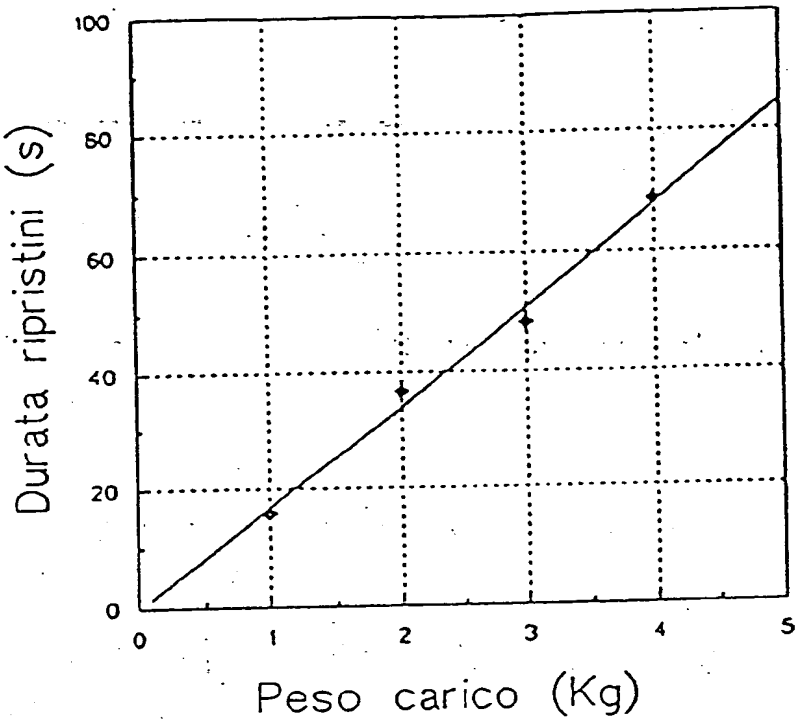

FIG. 4A

Dispersione dei valori della durata totale dei ripristini

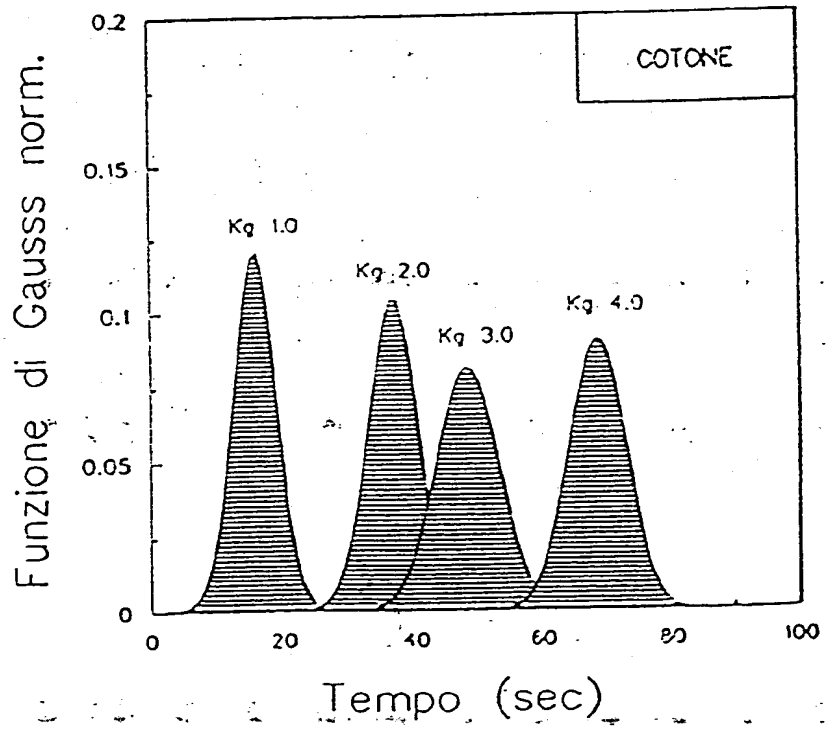

FIG. 4B

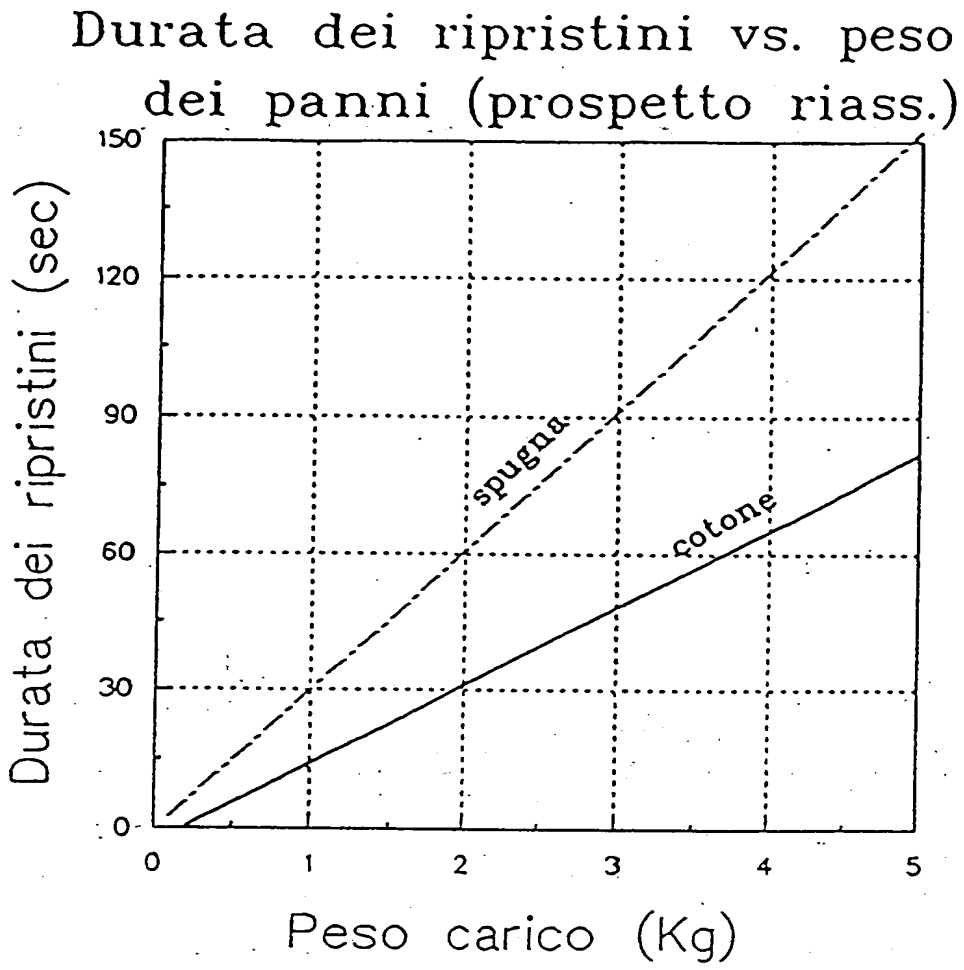

FIG. 5

TIPO/COLORE TESSUTO: SPUGNA — PRESSIONE ACQUA: 2 bar
QUANTITA' DI PANNI: 4.0 Kg

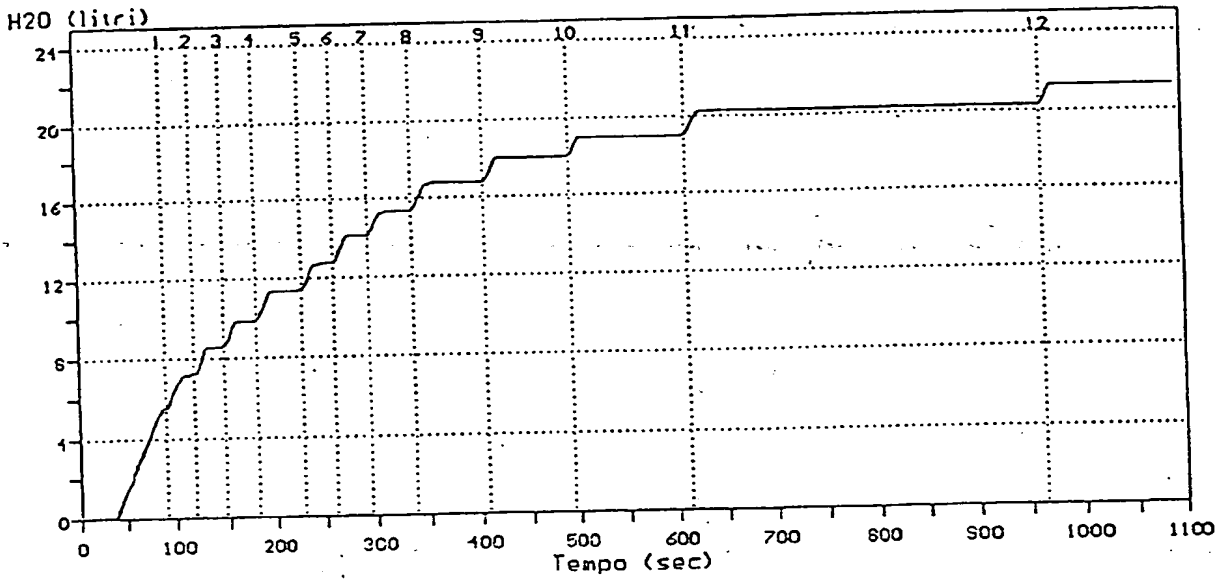

FIG. 6

TIPO/COLORE TESSUTO: COTONE PRESSIONE ACQUA: 2 bar
QUANTITA' DI PANNI: 4.0 Kg

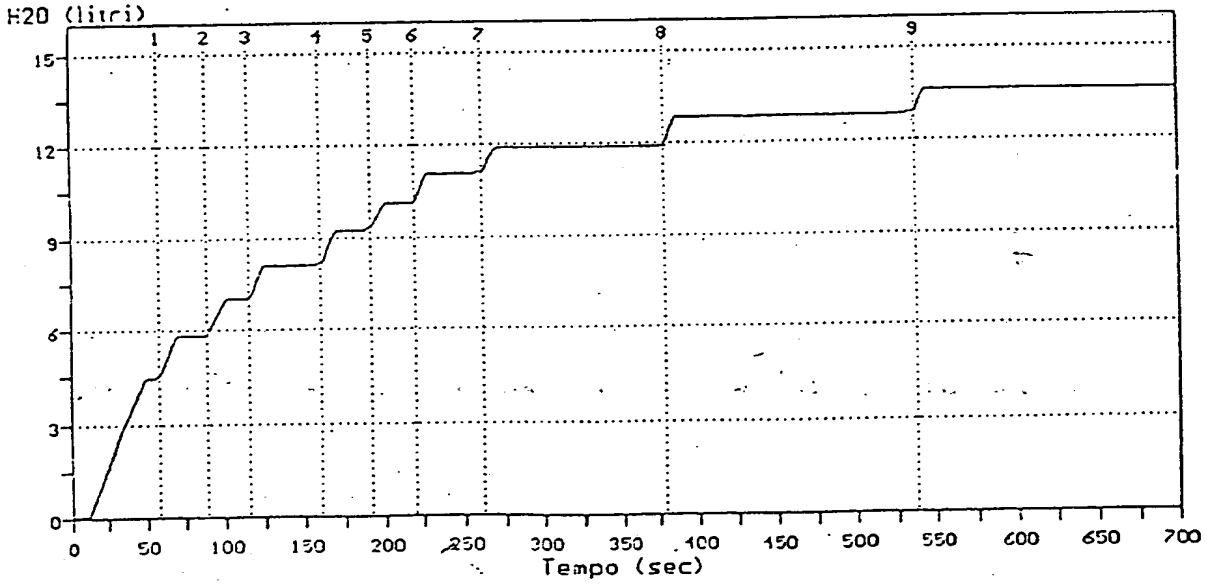

FIG. 7

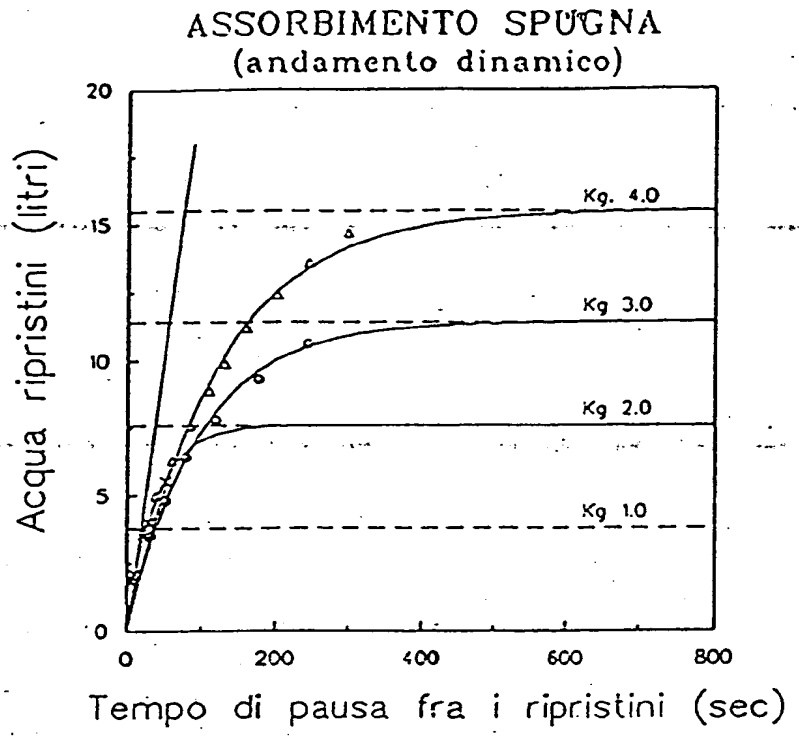

FIG. 8

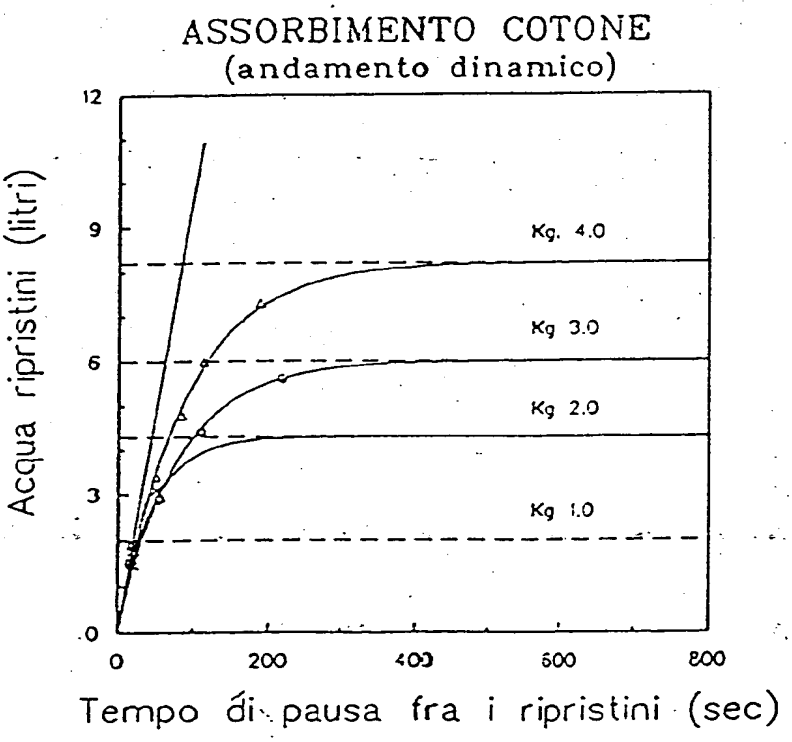

FIG. 9

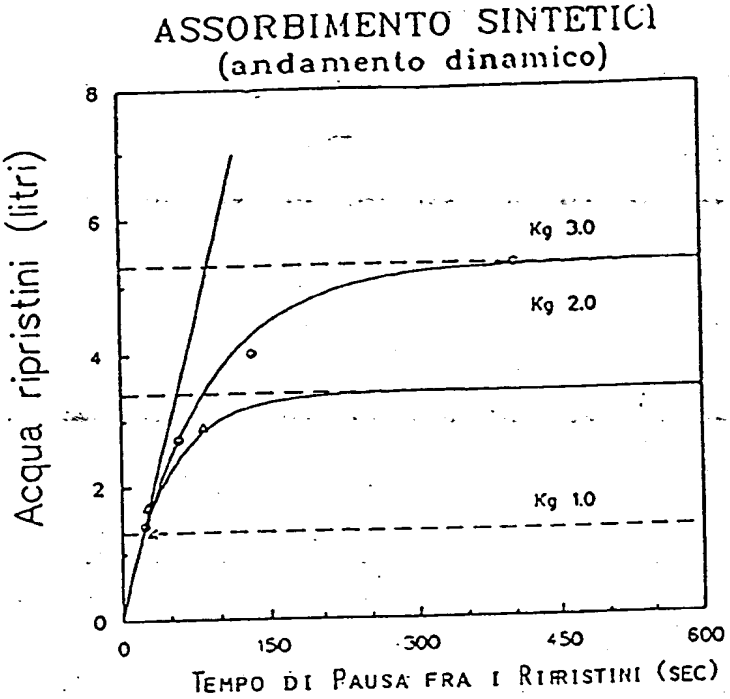
ASSORBIMENTO SINTETICI
(andamento dinamico)
Acqua ripristini (litri)
8
6
4
2
0
Kg 3.0
Kg 2.0
Kg 1.0
0
150
300
450
600
TEMPO DI PAUSA FRA I RIPRISTINI (SEC)

FIG. 10

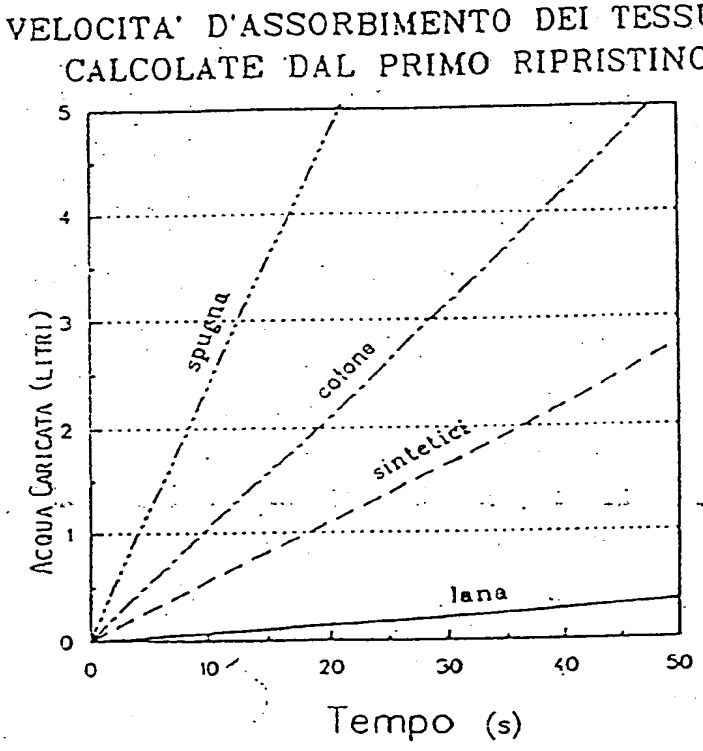
VELOCITA' D'ASSORBIMENTO DEI TESSUTI
CALCOLATE DAL PRIMO RIPRISTINO
ACQUA CARICATA (LITRI)
5
4
3
2
1
0
spugna
cotone
sintetici
lana
0
10
20
30
40
50
Tempo (s)

FIG. 11

CALCOLO DELLA VELOCITA' D'ASSORBIMENTO
DEI TESSUTI DAL PRIMO RIPRISTINO

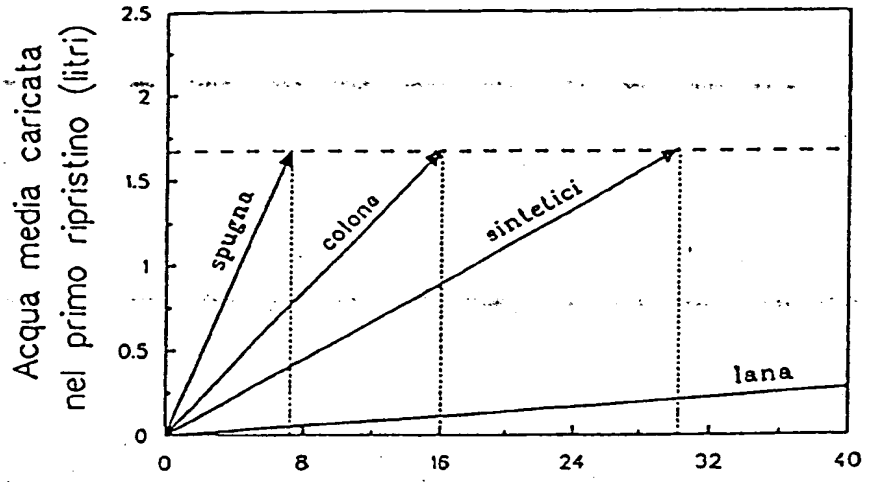

FIG. 12

DISTRIBUZIONE DATI TEMPO MEDIO
DI DURATA DI UN RIPRISTINO

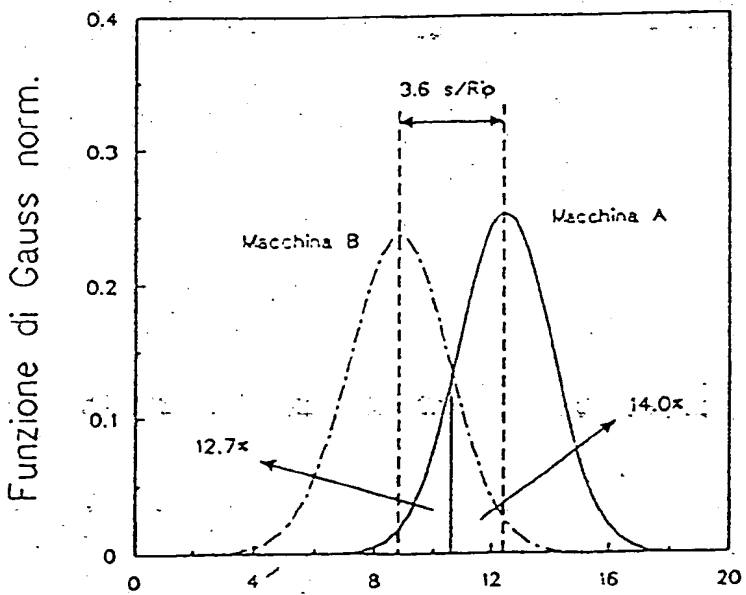

FIG. 13

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 11 6745

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-3 645 669 (G. RAUSCH) * column 2, line 37 - line 42 * * column 4, line 33 - line 58 * * column 5, line 55 - column 6, line 12 *	1-4	D06F39/00
A	* figures *	12,13, 15,16	

X	US-A-3 796 925 (W.C. BREEDING)	1-4	
A	* abstract; figures *	12,13, 15,16	

A	FR-A-2 474 547 (MIELE & CIE. GMBH.) * claims; figure *	6,8, 10-12	

A	EP-A-0 110 999 (N. GENJI & AL) * page 3, line 16 - page 4, line 2; figures *	7	

A	DE-A-41 22 307 (LICENTIA PATENT-VERWALTUNGS-GMBH) * abstract; figure *	8,9	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

D06F
A47L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26 January 1995	Courrier, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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